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(54) Method of controlling selection of tools in a machining center

(57) The method comprises sorting the required machining into point machining mode, line machining mode and surface machining mode in accordance with the machining shape. Each of the machining modes is classified into a plurality of machining units. A plurality of tool combination lines, each consisting of the names of the tools to be used in each machining unit, as well as the sequence of use of such tools, are stored in a tool combination memory. As the operator appoints one of the machining units, the tool combination line corresponding to the appointed machining unit is read out from the tool combination memory so that a series of tools to be used and the sequence of use of such tools are determined automatically within the machine in accordance with the thus read out tool combination line.

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FIG. 1

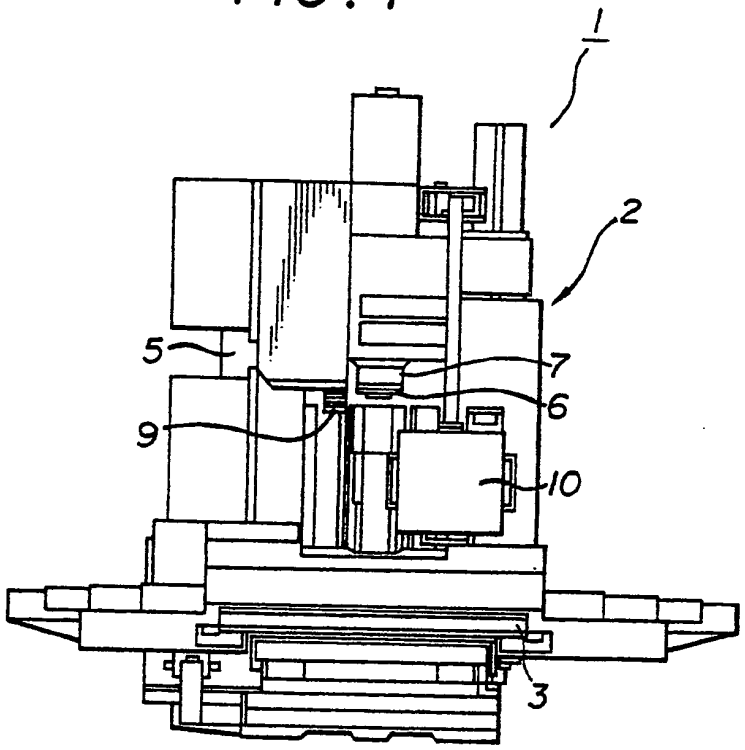
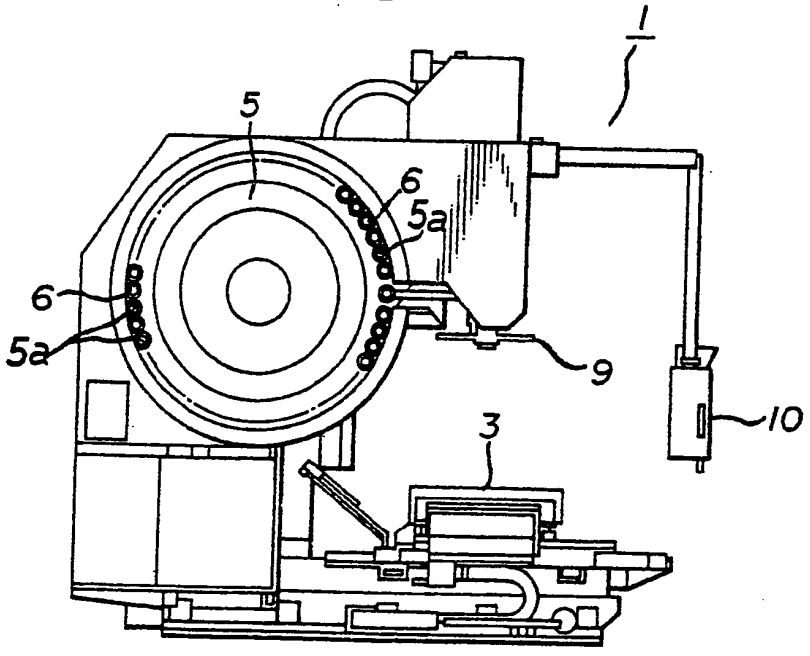


FIG. 2



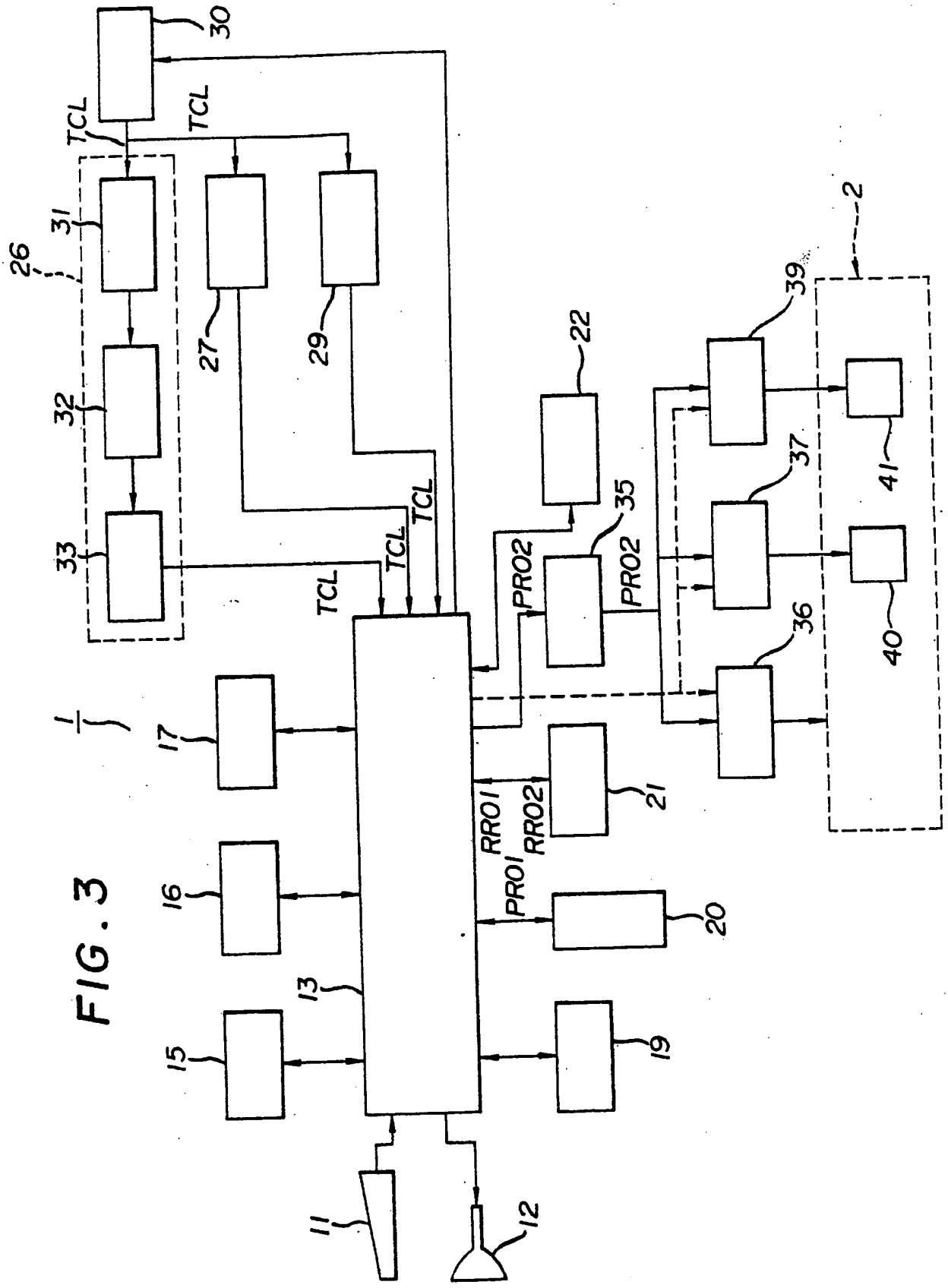

30
TCL
TCL
31
26
32
33
27
29
TCL
TCL
TCL
22
PR02
35
PR02
39
37
36
41
40
2
1
17
16
13
15
RR01
RR02
PR01
21
20
19
11
12

FIG. 3

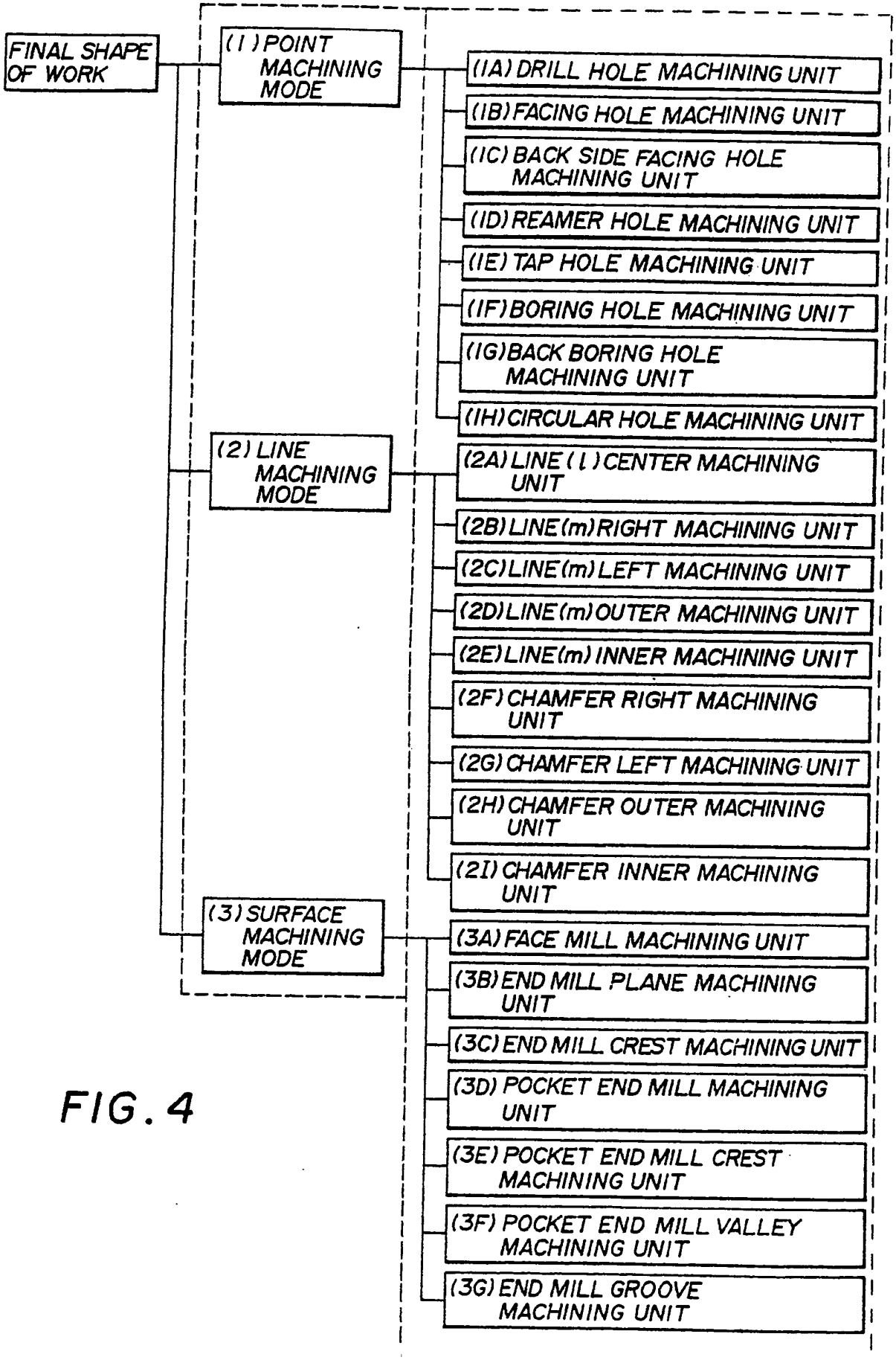

FINAL SHAPE OF WORK
(1) POINT MACHINING MODE
(1A) DRILL HOLE MACHINING UNIT
(1B) FACING HOLE MACHINING UNIT
(1C) BACK SIDE FACING HOLE MACHINING UNIT
(1D) REAMER HOLE MACHINING UNIT
(1E) TAP HOLE MACHINING UNIT
(1F) BORING HOLE MACHINING UNIT
(1G) BACK BORING HOLE MACHINING UNIT
(1H) CIRCULAR HOLE MACHINING UNIT
(2) LINE MACHINING MODE
(2A) LINE (l) CENTER MACHINING UNIT
(2B) LINE (m) RIGHT MACHINING UNIT
(2C) LINE (m) LEFT MACHINING UNIT
(2D) LINE (m) OUTER MACHINING UNIT
(2E) LINE (m) INNER MACHINING UNIT
(2F) CHAMFER RIGHT MACHINING UNIT
(2G) CHAMFER LEFT MACHINING UNIT
(2H) CHAMFER OUTER MACHINING UNIT
(2I) CHAMFER INNER MACHINING UNIT
(3) SURFACE MACHINING MODE
(3A) FACE MILL MACHINING UNIT
(3B) END MILL PLANE MACHINING UNIT
(3C) END MILL CREST MACHINING UNIT
(3D) POCKET END MILL MACHINING UNIT
(3E) POCKET END MILL CREST MACHINING UNIT
(3F) POCKET END MILL VALLEY MACHINING UNIT
(3G) END MILL GROOVE MACHINING UNIT

FIG. 4

FIG. 5

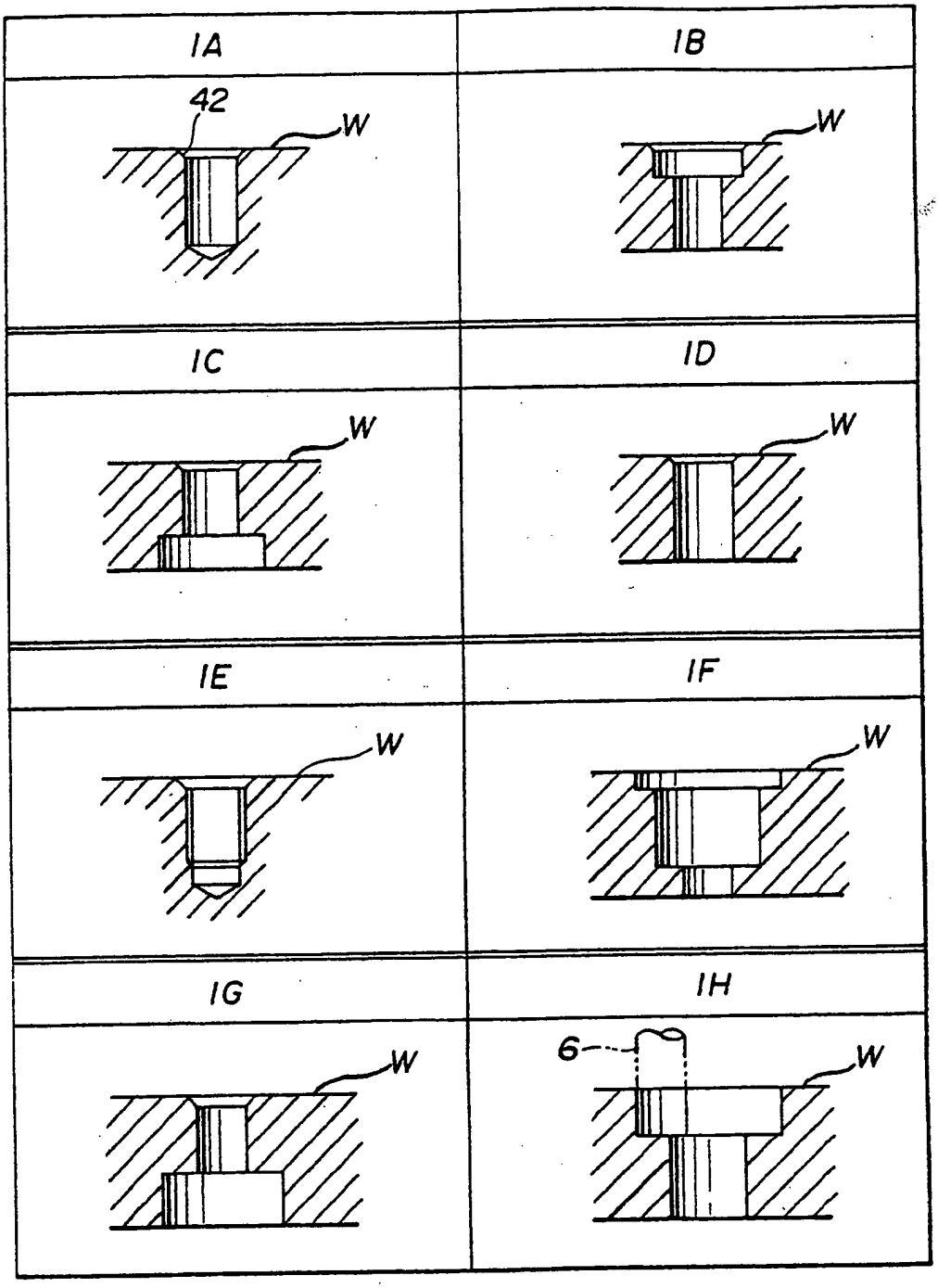


FIG. 6 (PART I)

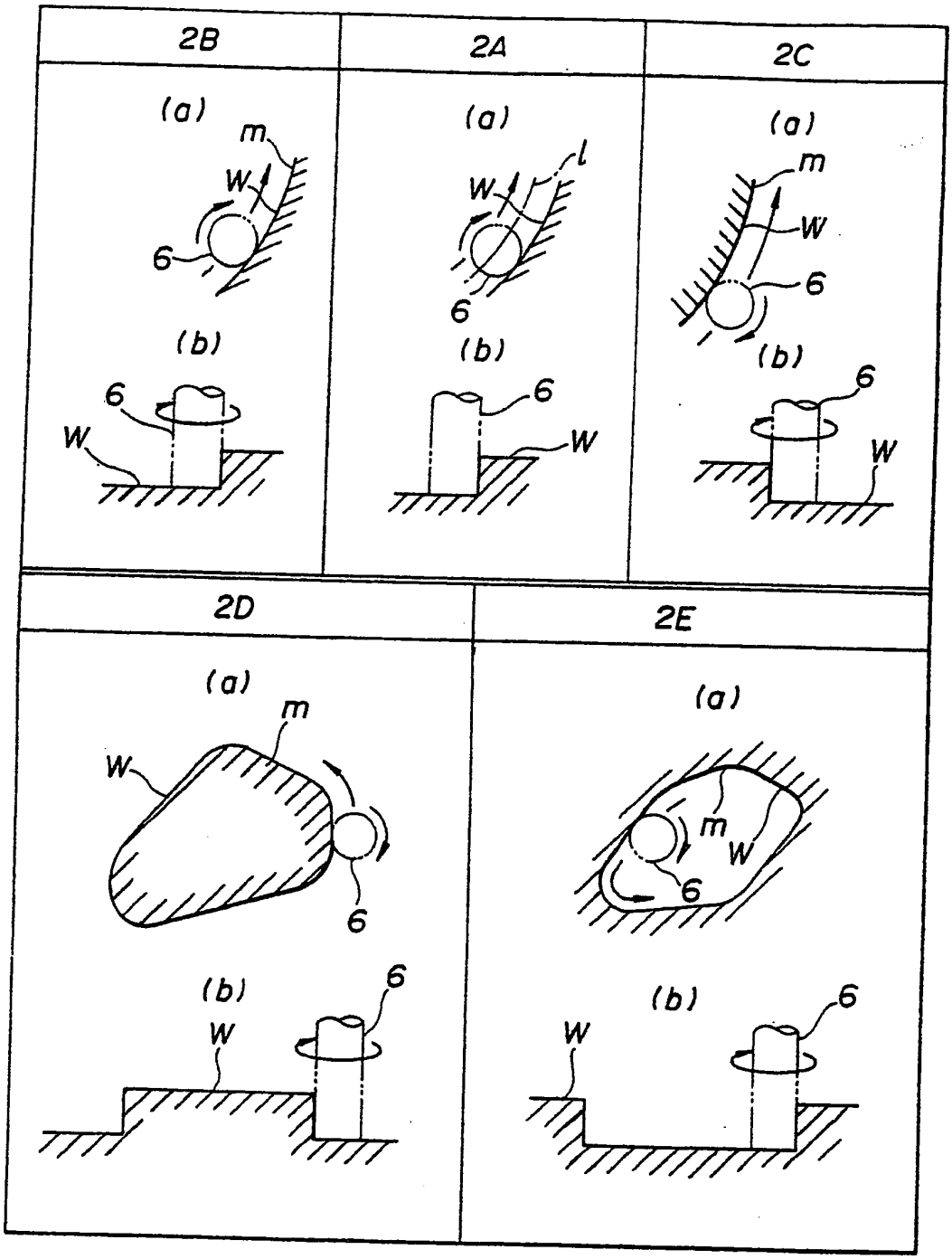


FIG. 6 (PART2)

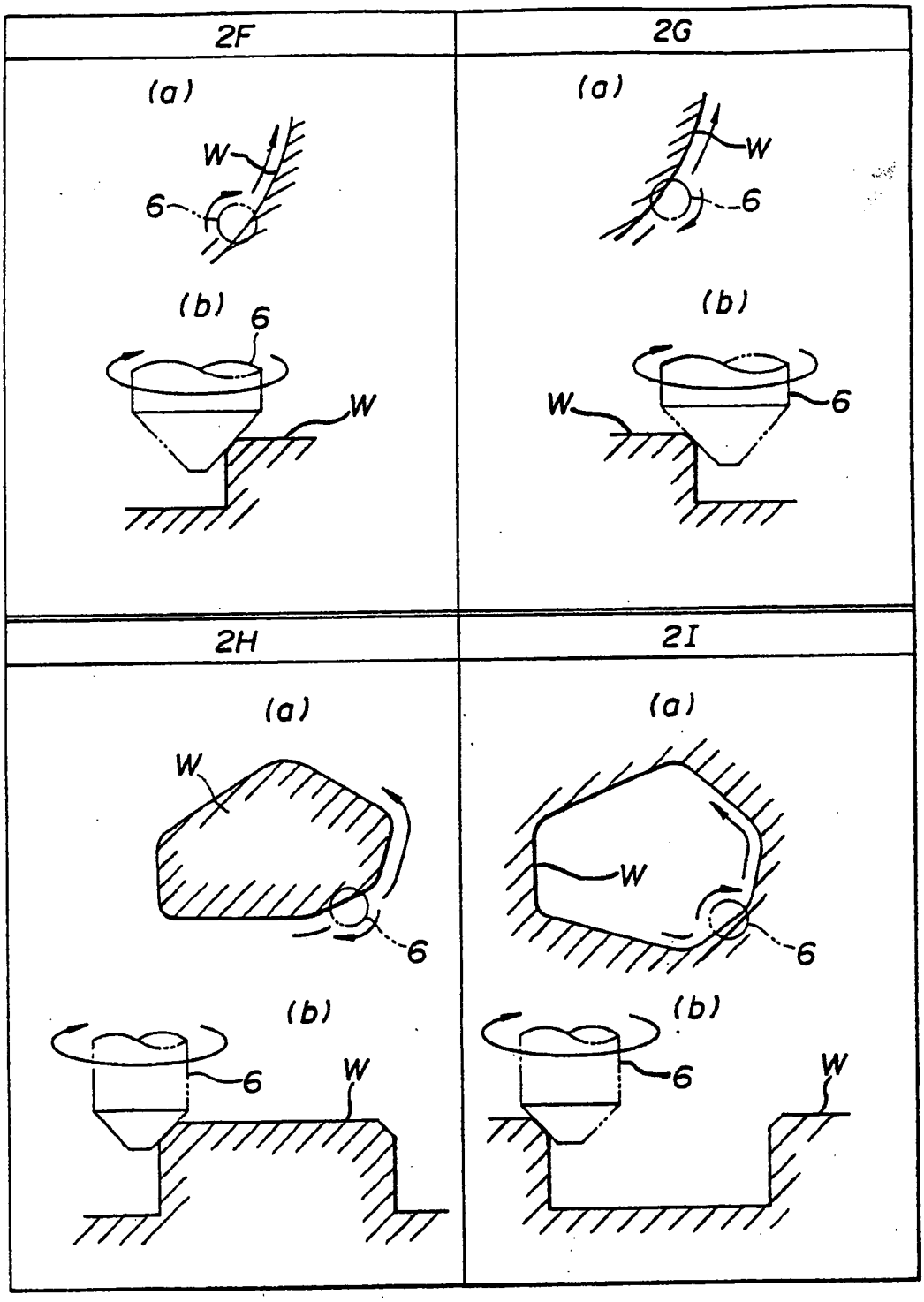


FIG. 7 (PART I)

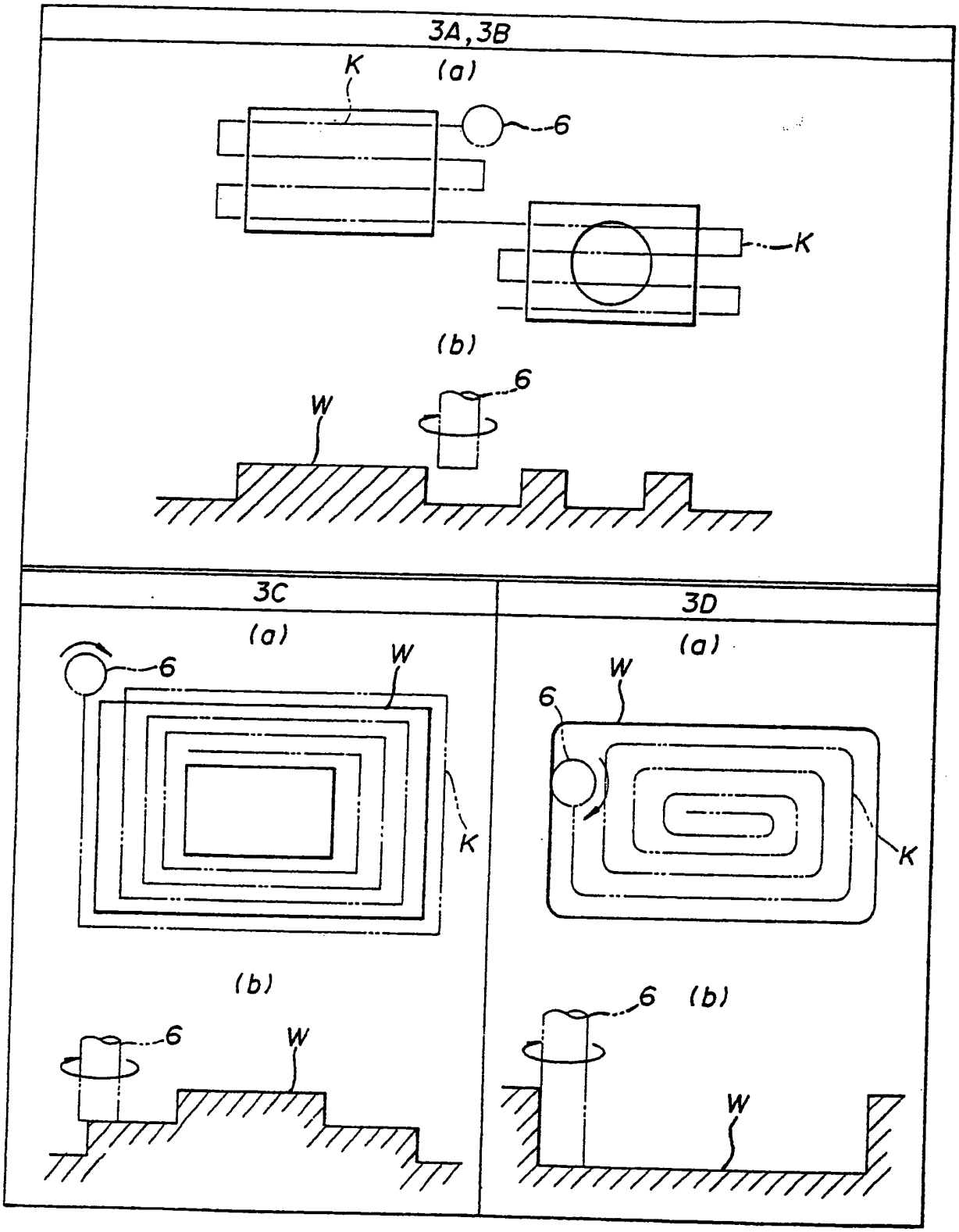


FIG. 7 (PART 2)

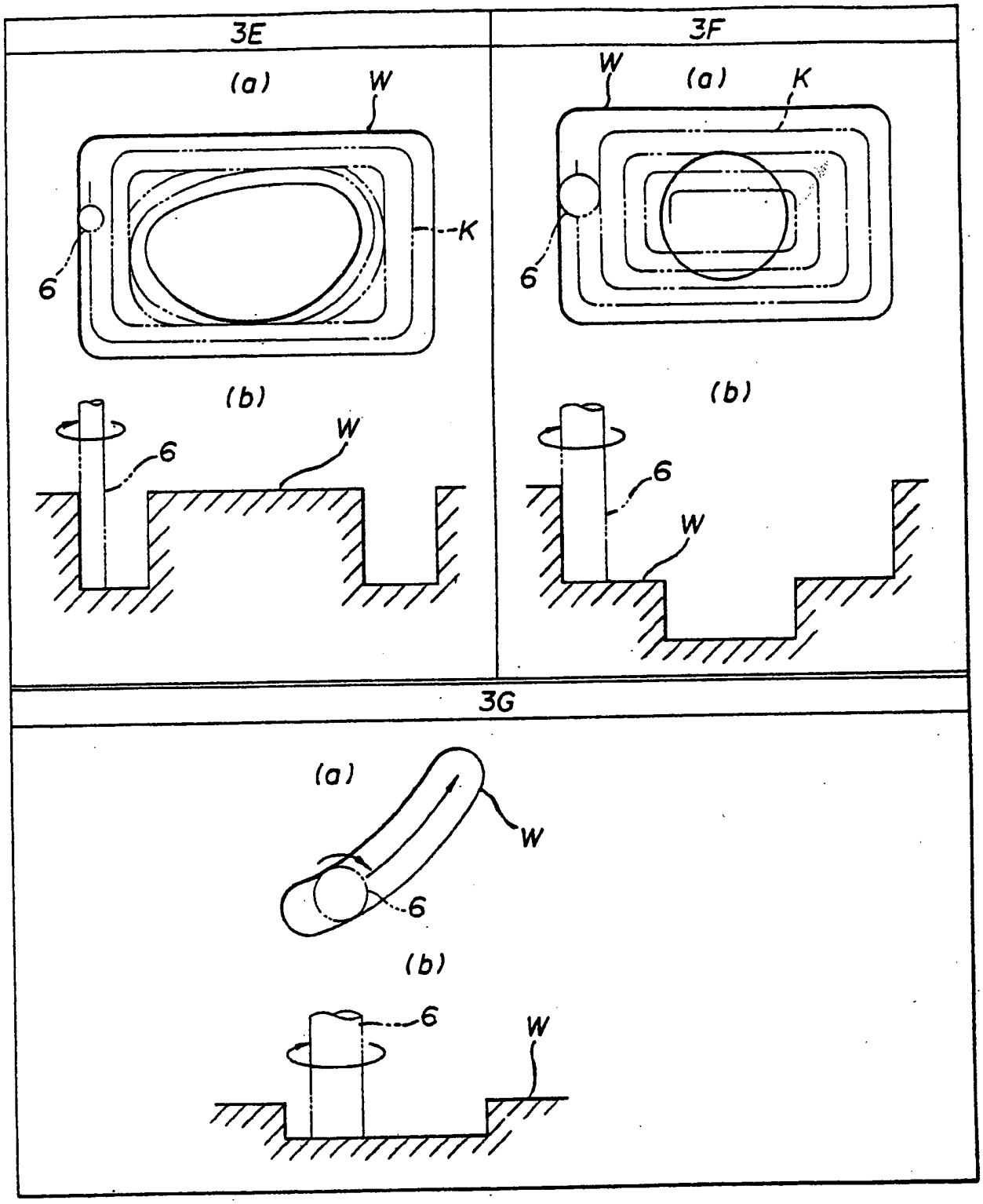
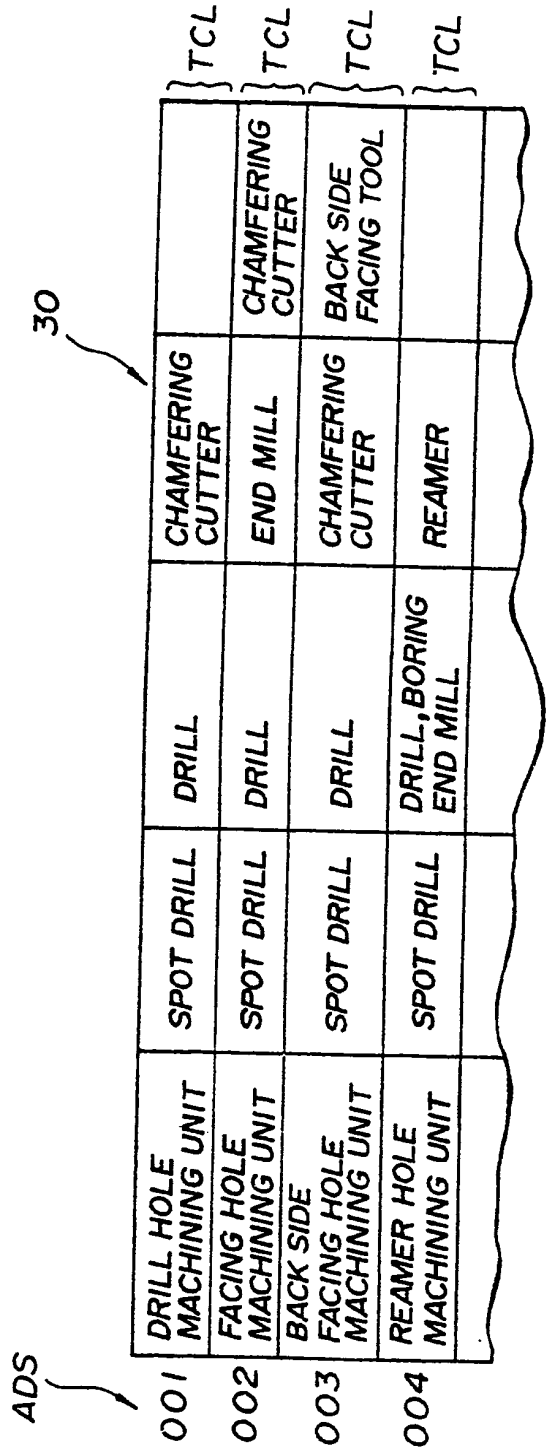


FIG. 8


ADS
30
001
002
003
004
DRILL HOLE MACHINING UNIT
FACING HOLE MACHINING UNIT
BACK SIDE FACING HOLE MACHINING UNIT
REAMER HOLE MACHINING UNIT
SPOT DRILL
SPOT DRILL
SPOT DRILL
SPOT DRILL
DRILL
DRILL
DRILL
DRILL, BORING END MILL
CHAMFERING CUTTER
END MILL
CHAMFERING CUTTER
REAMER
CHAMFERING CUTTER
BACK SIDE FACING TOOL
TCL
TCL
TCL
TCL

SPECIFICATION

Method of controlling selection of tools in a machining center

The present invention relates to a method of controlling selection of tools in a machining center.

Hitherto, for effecting a predetermined machining in a machining center, it has been necessary to give an instruction concerning the tool to be used to the machine in accordance with the machining shape at each time of the machining. Therefore, it has been an ordinary measure for the programmer to work out the machining program to be executed by the machining center by determining the kinds of tools to be used and the sequence of the use of these tools optimum for obtaining the final shape shown in the drawings. Such a programming process, however, is very time consuming and, in addition, requires a skilled programmer having abundant knowledge in the field concerned, besides the operator who actually manages the machine, in order to obtain satisfactory operation of the machine. This impractically restricts the spreading or popularization of the machining center.

According to the invention, there is provided a method of controlling selection of tools in a machining center comprising: sorting the required machining into point machining mode, line machining mode and surface machining mode, in accordance with the machining shape; classifying each of the machining modes into a plurality of matching units, storing, in a tool combination memory, tool combination lines containing the names of tools in the sequences of use for each respective machining unit; appointing one of the machining units to read out the tool combination line as a unit; and performing the appointed machining unit in accordance with the kinds of tools and sequence of use of these tools presented by the tool combination line.

Preferably, said point machining mode includes a drill hole machining unit, facing hole machining unit, back side facing hole machining unit, reamer hole machining unit, tape hole machining unit, boring hole machining unit, back boring hole machining unit, and circular hole machining unit.

Preferably, said line machining mode includes a line center machining unit, line right machining unit, line left machining unit, line outer machining unit, line inner machining unit, chamfer right machining unit, chamfer left machining unit, chamfer outer machining unit, and a chamfer inner machining unit.

Preferably, said surface machining mode includes a face mill machining unit, end mill plane machining unit, end mill crest machining unit, pocket end mill machining unit, pocket end mill crest machining unit, pocket end mill valley machining unit and an end mill groove machining unit.

The invention will now be more particularly described with reference to the accompanying drawings, in which:

Figure 1 is a front elevational view of an example of a machining center to which the method of the invention is applied;

Figure 2 is a side elevational view of the machining center as shown in Figure 1;

Figure 3 is a control block diagram of the machining center shown in Figure 1;

Figure 4 is an illustration of machining units for different machining modes;

Figure 5 is a front elevational view showing the machining shapes of machining units constituting a point machining mode;

Figure 6 shows machining shapes of various machining units included by a line machining mode, in which the parts having suffix (a) are plan views while the parts having suffix (b) are front elevational views;

Figure 7 shows machining shapes of various machining units included by a surface machining mode, in which the parts having suffix (a) are plan views while the parts having suffix (b) are front elevational views; and

Figure 8 is a schematic illustration of the content of a tool combination memory.

A preferred embodiment of the invention will be explained hereinunder with reference to the accompanying drawings.

As will be seen from Figs. 1 and 2, a machining center 1 to which the method of the invention is applied has a main body 2 and an X—Y table 3 which is movable in a horizontal plane in two orthogonal directions relatively to the main body 2. The X—Y table 3 can carry a work to be machined. A substantially disc-shaped magazine 5 is rotatably mounted on the main body 2. The magazine 5 is provided on its outer periphery with a plurality of magazine pockets 5a at a constant circumferential pitch. Each pocket is identified by an identification No. of its own, and is adapted to receive a tool 6. A spindle 7 is rotatably carried by a portion of the main body 2 above the X—Y table 3. A tool exchanger 9 disposed at the left side of the spindle 7 as viewed in Fig. 1 is adapted to withdraw from the magazine 5 a tool for the next step of machining process and mount the same on the spindle 7, while demounting the old tool 6 from the spindle 7 and returning the same into the magazine 5. A key board 11 and a display 12, which will be explained later, are provided on a control panel 10 which in turn is carried by the main body 2 of the machining center. As will be seen from Fig. 3, the key board 11 and the display 12 are connected to a main control unit 13 to which connected also are a material memory 15, machining mode memory 16, machining unit memory 17, cutting condition computing unit 19, machining program memory 20, program conversion unit 21 and a machining shape control unit 22. A point machining computing unit 26, line machining computing unit 27 and a surface machining computing unit 29 are connected to a tool combination memory 30. More specifically, the point machining computing unit 26 includes, in the form of a series connection, a center hole machining computing section 31 connected to a

tool combination memory 30, an intermediate machining computing section 32 and a chamfering machining computing section 33 connected to the main control unit 13. An excution program buffer memory 35 is connected to the main control unit 13. An auxiliary control unit 36, spindle control unit 37 and a shaft control unit 39 are connected to the buffer memory 35. The auxiliary control unit 36 is adapted to perform various auxiliary control functions such as control of driving of the magazine 5 and tool exchanger 9, turning on and off of the cutting water supply, and so forth. The spindle control unit 37 and the shaft control unit 39 are connected, respectively, to a spindle drive motor 40 and a plurality of shaft driving motors 41 to effect the drive control of these spindle and shafts.

For machining a work in the machining center 1 having the described construction, the main control unit 13 reads out the material table from the material memory 15 and displays the same on the display 12, to permit the operator to input the kind of material of the work through the key board 11. Then, the main control unit 13 reads out the machining mode to be performed from the machining mode memory 16 and shows the mode to the operator. As shown in Fig. 4, the machining modes are sorted into three kinds of machining modes: namely, a point machining mode which employs a drill or the like, line machining mode which employs an end mill or the like and a surface machining mode which employs a face mill or the like tool. The operator then examines the final shape of the work in the drawing and makes a judgement as to which one of these three machining modes the machining to be performed first belongs, and inputs the selected machining mode through the key board 11. As a result, the main control unit 13 makes a display on the display 12 the machining unit corresponding to the selected machining mode, so that the operator can judge to which one of the displayed machining units the machining shape shown in the drawing belongs, and appoints and inputs the appropriate machining unit. Namely, the machining unit memory 17 stores, as shown in Fig. 4, a plurality of machining units 1A to 1H, 2A to 2I and 3A to 3G for each machining mode. The machining shapes of respective machining units 1A to 1H of the point machining mode are illustrated in Fig. 5. Similarly, the machining shapes of machining units 2B to 2I of the line machining mode are shown in Fig. 6, while the machining shapes 3A to 3G of the machining units belonging to the surface machining modes are shown in Fig. 7. In the drawings, a reference numeral 6 designates a tool, while symbols W and K represent the work and the locus of the center of the tool. Since almost all of the patterns of machining achievable in the machining center 1 is covered, the operator can immediately select and input the suitable machining unit by checking up the final shape of the work in the drawing with the machining shapes displayed on the display. Upon receipt of the input of the machining unit, the main control unit 13 reads out of the tool combination memory 30 a tool combination line TCL corresponding to the selected machining unit, and outputs the same selectively to one of the machining computing units 26, 27 and 29 which has been selected beforehand.

More specifically, the tool combination memory 30 stores, as shown in Fig. 8, the names of the tools to be employed in execution of each machining unit in a row from the left to the right side in the form of a tool combination line TCL, in each address ADS. The arrangement is such that, once a machining unit is appointed, the tool combination line TCL corresponding to the appointed machining unit is delivered to the corresponding one of the computing units 26, 27 and 29. Assuming here that the operator has inputted a drill hole machining unit which is of the point machining mode, the main control unit 13 reads a series of tools, i.e. the tool combination line TCL, consisting of a spot drill, drill and a chamfering cutter which are used for the drilling, from 001 of the address ADS in the memory 30, and the tool combination line TCL thus read out is delivered as a unit to the point machining computing unit 26. Then, the center hole machining computing section 31 computes the diameter of the spot drill to be used first, from the machining data such as hole diameter which is inputted by the operator through the key board 11. The computing section 31 determines also whether the chamfering can be made simultaneously with the center boring, through comparing the hole diameter and the diameter of the spot drill. Namely, if the diameter of the spot drill is greater than the diameter of the drill hole, it is possible to machine the chamfer portion 42 simultaneously with the machining of the center hole in Fig. 5 by means of the spot drill. Then, the intermediate machining computing section 32 computes the diameter of the drill to be used subsequently to the spot drill and the pattern of use of the drill, e.g. penetration per cycle, total penetration and so forth. Meanwhile, the chamfering machining computing section 33 computes the diameters of the chamfering cutter to be used for the chamfer portions 42 of holes other than the hole in which the chamfering is conducted by means of a spot drill. The result of the computation is delivered through the main control unit 13 to the cutting condition computing unit 19 which in turn computes and determines the cutting condition such as feed speed and peripheral speed for each tool. These data are stored, together with the tool combination line TCL delivered by the point machining computing unit 26 containing the detailed data such as tool diameters, in the machining program memory 20. The thus stored data and tool combination line TCL form a machining program PRO1. Then, a demand is displayed on the display 12 through the shape control unit 22 for the inputting of the machining position information. In response to this demand, the operator inputs the required data through the key board 11. The inputted values are

stored as the machining position information in the machining program PRO1. Thus, the operator appoints and inputs the machining unit for each machining mode and, at each time of the inputting, the tool combination line TCL corresponding to the appointed unit is read out from the tool combination memory 30. Then, the tool diameters and the cutting conditions are determined in accordance with the tools and the sequence of use of the tools presented by the tool combination line TCL, and are stored in the program memory 20 together with the machining position information. For other machining units, the intermediate machining computing section 32 determines the diameters of tools such as end mill, boring, tap, reamer and so forth presented by the tool combination line TCL, as well as the pattern of use of these tools, for the machining of holes other than the center hole drilling and chamfering, and the line machining computing unit 27 and the surface machining computing unit 29 determine, from the tool combination line TLC read out from the tool combination memory 30 (the tool combination line TCL may contain only one tool), the number of tool blades and shapes corresponding to the extent of finishing which is given by the operator through the key board 11. In addition, the surface machining computing unit 29 determines the detail of data concerning the tools taking into account also the machining direction. In accordance with these data, the cutting condition computing unit 19 computes the cutting conditions and stores the thus determined conditions as the machining program PRO1 in the memory 20. The inputting of a series of machining units for one work is thus completed. Then, the main control unit 13 reads out the machining program PRO1 from the memory 20, and the read out program is converted by the program conversion unit 21 into an execution program PRO2 in terms of machine code. The execution program PRO2 is then stored in the execution program buffer memory 35. Thereafter, the operator puts the work W on the X—Y table 3 and instructs the main control unit 13 through the control panel 10 to start the machining. In response to this instruction, the main control unit 13 drives the auxiliary control unit 36, spindle control unit 37 and the shaft control unit 39 so that the required machining is executed in accordance with the execution program PRO2. Needless to say, therefore, the machining is conducted in conformity with the machining program PRO1. In the execution of each machining unit, tools 6 are picked up from the magazine 5 and mounted on the spindle 7 by means of the tool exchanger 9 to perform the machining in accordance with the sequence of use of the tools presented by the tool combination line TCL which is read out from the tool combination memory 30.

On the other hand, during the machining of the work W, the operator takes out the drawing of the work W to be machined subsequently to the work under the machining, and works out the new machining program PRO1 through the key board 11 in the same procedure. The machining program memory 20 usually has a capacity large enough to contain a plurality of programs for ordinary machining of work W, so that it is possible to input a new machining program PRO1 for the new work W even when the machine is conducting the machining of a work W. It will be understood that the operator can work out the program by making an efficient use of the machining time.

As has been described, the tool combination line TCL in which the names of the tools to be used are arrayed in the order of the use is stored for each machining unit in the tool combination memory 30, so that the data concerning a series of tools constituting the tool combination line TCL are read out as a unit from the memory 30 by an appointment of the machining unit. Therefore, the kinds of the tools required for performing each machining unit are determined in the sequence of the use simply by an appointment of the machining unit made by the operator in accordance with the machining mode.

It will be understood from the foregoing description that the present invention greatly contributes to the automation of the programming work in machining center 1.

Although the invention has been described through specific terms, it is to be noted here that the described embodiments are not exclusive but only illustrative, and various changes and modifications may be imparted thereto without departing from the scope of the invention which is limited solely by the appended claims.

CLAIMS

1. A method of controlling selection of tools in a machining center comprising: sorting the required machining into point machining mode, line machining mode and surface machining mode, in accordance with the machining shape; classifying each of the machining modes into a plurality of machining units; storing, in a tool combination memory, tool combination lines containing the names of tools in the sequences of use for each respective machining unit; appointing one of the machining units to read out the tool combination line as a unit; and performing the appointed machining unit in accordance with the kinds of tools and sequence of use of these tools presented by the tool combination line.

2. A method of controlling selection of tools in a machining center according to claim 1, wherein said point machining mode includes a drill hole machining unit, facing hole machining unit, back side facing hole machining unit, reamer hole machining unit, tap hole machining unit, boring hole machining unit, back boring hole machining unit, and circular hole machining unit.

3. A method of controlling selection of tools in a machining center according to claim 1, wherein said line machining mode includes a line center machining unit, line right machining unit, line left machining unit, line outer machining unit, line inner machining unit, chamfer right machining

unit, chamfer left machining unit, chamfer outer machining unit, and a chamfer inner machining unit.

4. A method of controlling selection of tools in a machining center according to claim 1, wherein said surface machining mode includes a face mill machining unit, end mill plane machining unit, end mill crest machining unit, pocket end mill machining unit, pocket end mill crest machining unit, pocket end mill valley machining unit and an end mill groove machining unit.

5. A method of controlling selection of tools in a machining center as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

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